Recent Trends in the Analysis of Quasioptical Systems

D. J. Hoppe and W. A. Imbriale
Jet Propulsion Laboratory

The recent trend in microwave instruments is the use of multiple millimeter and submillimeter wavelength bands. These systems are typically analyzed by using physical optics, Gaussian beams or ray tracing techniques. Physical optics offers high accuracy at the expense of computation time. This trade-off becomes particularly apparent in the analysis of multiple reflector antennas, such as beam waveguide antennas, where physical optics is used to compute the current on each reflector from the current on the previous reflector. At the other end of the spectrum is ray tracing approaches that ignore diffraction effects entirely. These methods are fast but sacrifice the ability to predict some effects accurately.

An intermediate approach is to use an appropriate set of expansion functions to model the field between the reflectors. If the set is chosen wisely only a few coefficients need to be determined from each reflector current. The field is then computed at the next reflector through the use of the expansion functions and their coefficients rather than by using the previous reflector current. For a beam waveguide system with no enclosing tubes an excellent set of expansion functions is the Gaussian beam mode set. In many cases a preliminary design which includes the effects on diffraction may be obtained by considering only the fundamental mode and a thin lens model for the reflectors. Higher-order modes are included to model the effects of the curved reflector, which include asymmetric distortion of the beam, cross polarization, and beam truncation.

This paper describes a computer code implementing higher-order Gaussian beam scattering by multiple reflector systems. There are four essential steps in the algorithm. (1) Compute the current on the first reflector using physical optics using either a feed model or by an incident set of Gaussian beam modes. (2) Find the direction of propagation for the reflected Gaussian beam-set using ray tracing. (3) Determine the waist size and location for the output beam set by examining the amplitude and phase distribution of the current on the reflector. (4) Compute the amplitudes of the individual modes in the output mode set. These steps are then repeated for each addition reflector in the chain. In each of these cases the previous Gaussian beam set provides the input field for the current calculation.

Details of the four steps discussed above will be discussed. Examples will compare results from the Gaussian beam approach to pure physical optics, illustrating both its merits and limitations. Hybrid approaches capable of eliminating some of the limitations will also be discussed.